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Future Scientists and Engineers Club at Tech High

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Future Scientists and Engineers Club

At

Worcester Technical High School

An Interactive Qualifying Project Report

Submitted to the Faculty of the

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the Degree of Bachelor of Science

by

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Submitted 2/20/08

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Report Abstract

The “Future Scientists and Engineers Club” was continued at Worcester Technical High School to assist juniors at the school in learning more about the fields of science and engineering. This club ran simultaneously with clubs at the other four Worcester public high schools, but unlike those clubs, ran during the school day. This and the other four clubs were successful in different ways and should all be continued in school years to come.

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Professor T. H. Keil, our advisor throughout the project, was indispensable in this project. His careful guidance and thoughtful suggestions made this entire project possible, and made the entire ordeal much simpler for all those involved.

Amanda Cox, the student sponsor of the project, organized all of the data from the previous years and played a huge role in the infrastructure of the project. In addition to organizing the CORI forms, scheduling meetings, and organizing the entire project from the start, Amanda was a helpful resource whenever help was needed somewhere in the project. She also devoted a lot of time to finding outside resources and groups to aid in the objectives of each project.

Mr. Thomas Gusek, our sponsor at Worcester Technical High School, and Mr. Azad Chaparian, the Science Department Head at Worcester Technical High School, who both oversaw our work at the school. Mr. Chaparian was very helpful at setting us up with a class of students that would work best for the school and our project, and Mr. Gusek allowed us to utilize some of his class time in addition to meeting with us outside of class to make sure we had the resources we needed to succeed. Without any of the aforementioned individuals, this project would not have proceeded nearly as smoothly as it did.

I. Introduction

A. Overview

This project stemmed from the original idea of starting a “Future Scientists and Engineers Club” in the high schools of the Worcester public school system. The project started as an Interactive Qualifying Project in the 2005-2006 school year at Doherty Memorial High School. In the 2006-2007 school year, the project expanded to all five of the public high schools in Worcester. For the project this year, a group of eleven students formed to continue the program at each of the five schools. We split up into teams of two and three and randomly chose schools. The other four schools held the clubs as after-school activities. Our group, at Worcester Technical High School (WTHS), could not do that because most of the students are encouraged to take on internships and apprenticeships after school. Instead, we worked with the science department to make a plan for the club to be held during the school day where we would aid the teacher in various tasks, such as labs, and collect data about the preferences and working habits of students in the meantime. The project was an overall success, and should be continued in the future with the recommendations made at the end of this paper.

B. Project Purposes

The project proposed to us was to complete a gender study of students interested in science and engineering at WTHS. As the previous year’s group had done, we decided to continue the “Future Scientists and Engineers Club” during the school’s honors mechanical physics class. The previous year’s sponsors passed down to us that the number of women interested in careers in science and technology is significantly higher

among 8th graders than 11th graders. Their goals were to stimulate interest in those areas of study among females during the critical first three years of high school. Our project was an attempt to discover what teaching techniques help to stimulate females and racial minorities, who are also underrepresented, in science and engineering careers. Also, to make this project beneficial to the school, science department, and its current students we wanted to reduce the workload of the teacher we worked with by planning labs and demonstrations and setting up equipment for the labs. Assisting with set-up would also help the teacher run more labs during the year since his schedule was not conducive to doing any preparation before his class as he had four different classes in a row every day.

C. Literature Review

College-level science and engineering programs have more male students than female, and more white and Asian students than African-American and Latino students. This disparity in gender and race among science and engineering students is explained by the success and choices of students in high school. From a study done with about 24,000 students in over 1000 public school systems, males in every ethnic group showed a higher growth rate in science achievement between 8th and 12th grade than females in the same group. Likewise, white and Asian students outperformed their African-American and Latino Counterparts in the same areas of study. This disparity of the development of interest and performance in science compounds the pre-existing one initially noted among students in 8th grade (Muller; Stage; Kinzie).

The explanation for the gender gap is being slowly uncovered. Some factors being studied include the amount of time spent passively working (doing homework, reviewing

material), passive lab work (watching the teacher perform an experiment), and participating in hands-on laboratory work. Girls, on average, reported less time in hands-on activities and more time passively working. Teachers did not report any differences in the activities done for each gender, so the reported differences were likely based on the perceptions of the students, or perhaps that boys had a greater tendency to actively participate in experiments while girls watched (Burkam; Lee; Smerdon).

The original idea for this project was to attempt to find a correlation between gender or race and learning styles. One of the goals of the project in previous years was to attract females who were interested in exploring the possibilities of technical careers and encouraging them to pursue those ambitions, but we were more focused on building a solid foundation for the club to continue in the future. We decided to build from their goal of attracting female and minority students into science fields by studying how those underrepresented groups learn best. The hope was that this knowledge could later be used to make science classes more appealing to women and minorities.

Because our club met during a class, we knew from the start that we would have limited lab availability and would only be doing physics labs. The science department officials made it clear that, at WTHS more so than other public schools due to their unique schedule, there was very little time to stray from the curriculum. The fact that the curriculum dictated what labs we would do prevented us from studying how different students perform in different sciences. Also, unlike the clubs at other schools, all students registered for the class were required to attend every day. This requirement prevented us from gathering data based on who wanted to join the club, and, from those students, who continued participating throughout the duration of the program.

These limitations led us to the idea of placing the students in different sized lab groups to focus on teaching styles. We thought that it would be beneficial to see which students might not actively participate if the class were in one or two large teams but would lead the group if there were only a few students, and who would thrive while working alone. If a trend was discovered, teachers could modify their styles to suit the needs of their class and also to encourage women and minorities to think about science and engineering.

D. WTHS Background

The city of Worcester, MA is home to five public high schools: Doherty Memorial, Burncoat Senior, North, South Community, and Worcester Technical High School. The former four are average four-year public high schools; the latter is a four-year vocational school and the subject of this paper. Enrollment into WTHS, like most vocational schools, follows a different process from the other schools in Worcester, as students are required to apply well in advance in order to attend, whereas the other four schools take all of the students in their district. Once accepted, students apply for a trade or major, which they study in-depth. There is no guarantee that a student will be accepted into their chosen trade, as caps must be set depending on available equipment and subject matter. Most students either find a job related to their trade upon graduation or attend two-year public colleges in order to study it more closely before seeking employment (Massachusetts Department of Education). An important part of the experience of many students at WTHS is participation in an apprenticeship after school. Most students use this field experience to supplement their education. As a result, many students do not

partake in after-school activities, which is what necessitated this project to be done during school hours. This is not to say, however, that there are no after-school sports or activities, as there are indeed many, including a baseball team, student council, and DECA chapter (Worcester Technical High School).

The school itself is physically well-structured for the purpose it serves. The building is still very new, having opened in August 2006. It was designed with function in mind. The school is divided into four sub-schools, each with six vocations. One assistant principal and guidance councilor are assigned to each sub-school, which also gets its own wing of the building (McFarlane). The students are divided into two groups: one focuses on trades one week while the other works on academics, and then the two groups switch the next week. This ensures that each student gets a good balance of academic and trade work. The schedule takes holidays and other days off into account to be sure that one group does not get more of one session than the other.

According to the Massachusetts Department of Education, WTHS has a very diverse student population. The total school population is 1,200 students. The gender balance is in favor of males, with a balance of 679 males to 512 females. Racially, the school has the highest percentage of white and Native American students of any school in Worcester at 52.8% and 1.3%, respectively. The remainder of the school is 7.4% black, 1.9% Asian, 35.6% Hispanic, and 0.9% other. As mentioned earlier, most students at the school elect to find a job immediately after high school or attend a two-year college, with 23% and 52% respectively choosing these two paths. Another 17% plan to attend a four-year college, with 4% planning on joining the military and 2% having other plans. One remarkable aspect of the school, however, is the forethought each students exhibits. Less

than 1% of students at WTHS do not know what they want to do after graduation, which is substantially lower than the state average of 7% (Massachusetts Department of Education). While this type of statistic speaks volumes about the quality of the education students receive at WTHS, there are many other positive observations to go along with it. Perhaps the most striking comes concerning the MCAS tests administered to all Massachusetts students. Of all of the high schools in Worcester, WTHS showed largest improvement in test scores, with 46% of students scoring proficient in English compared to 27% last year and 20% scoring advanced in math this year compared to 10% last year. On the other end, failures were cut in half, going from 14% last year to 7% this year. WTHS was actually the only high school in the city to meet the rigorous No Child Left Behind standards. Many accredit this to the school's excellent student-teacher ratio of 9.6:1-the lowest in Worcester (the school has 126 teachers-95.6% of which are licensed and 94.2% of which are regarded by the State of Massachusetts to be "highly qualified") (McFarlane). Statistics such as this prove that the school is an excellent place for an education.

Table 1: Summary of Worcester Public High Schools Composition

Category	WTHS	Burncoat	Doherty	North	South
Total Students	1,200	1,363	1,560	1,203	1,443
Males:Females	679:521	667:696	747:813	646:557	721:722
% White	52.8%	47.3%	52.4%	37.2%	33.7%
% Black	7.4%	16.9%	13.6%	19.0%	14.3%
% Hispanic	35.6%	30.4%	26.7%	35.6%	38.8%
% Asian	1.9%	4.2%	6.3%	7.3%	12.6%
% Nat. Amer.	1.3%	0.7%	0.5%	0.2%	0.1%
%Low Income	59.3%	51.2%	39.4%	68.2%	69.8%
% First Language not English	30.4%	34.5%	37.8%	42.7%	53.2%
% Limited English Proficiency	2.5%	9.6%	4.6%	6.7%	14.2%
% Graduation	79.3%	63.7%	72.1%	67.0%	63.4%
% Attending Private 4-year college	8%	30%	21%	21%	19%
% Attending Public 4-year college	9%	17%	36%	25%	20%
% Attending Private 2-year college	5%	2%	1%	1%	1%
% Attending Public 2-year college	47%	24%	29%	34%	42%
% Entering Job Market	23%	14%	5%	6%	10%
% Entering Military	4%	3%	1%	2%	1%
%Unknown/Other	4%	9%	8%	13%	15%

(Data Taken from the Massachusetts Department of Education)

E. Goals

The goals for this project are as follows:

1. To establish a better understanding of how different students learn based on ethnicity, gender, post-secondary educational plans, educational focus, and family background.
2. To determine whether any of the aforementioned demographic groups will function better in groups of certain size.
3. To determine whether students of different ethnicities and genders have a preference when it comes to working with students of ethnicities or genders the same as or different than their own.
4. To determine whether the introduction of competition will have an effect on the performance of certain demographic groups.
5. To assist in the learning process of the students with whom we interact.
6. To stimulate the interest of students in science and engineering and encouraging them to continue in these fields.

One thing that all of the groups were interested in was motivating the students that we were working with to go to college. In the Worcester public school system, college is far less emphasized than it is in the high schools that we attended. Most suburban school systems emphasize that college is the standard path after high school, whereas only 79% of the Worcester public high school students plan on attending a 2- or 4- year college. This is even more common in WTHS; only 69% of students plan on attending college after graduation.

Since we worked in an honors physics class, our students were some of the best students academically at WTHS. One of the goals of Mr. Gusek, the physics teacher in whose class we worked at WTHS, goals was to encourage these students to go to college since they are the most likely among WTHS students to succeed there. He wanted us to serve as role models for the students because we are close to them in age and thus easy to relate to. Many of these students, he reasoned, lack good influences in their lives and we could fill this gap.

One of our ideas to accomplish this goal was a “college talk”. We wanted to go into the classroom to talk to each class once about college admissions and life. We planned to try to emphasize that going to college now will change their lives forever. We also wanted to tell them that college is fun and that the benefits by far outweigh the work. Our original plan was to do this visit after one or two labs with each group of students. We decided that they would not likely see us as the role models we were hoping to be if we started the project off with a lecture. Unfortunately, because we did not get into the school as early as planned, we did not have the time to have this discussion.

Another one of our goals was to maintain and improve contact with the high school. This was very successful. One major problem was that we lost contact with the schools at various points throughout the project. Mr. Gusek was also concerned that if he let us borrow lab manuals or computer software to prepare labs we might not come back to the school and he would lose his materials. By the third term of the project, we had continued e-mailing him asking when he wanted us to work with the students that he trusted that we were determined to be in the classroom and that he would have no trouble getting his materials back.

Every time that we entered WTHS, we had to sign in at the main office as is standard at most high schools. During classroom visits, he would have to dismiss a student from class to meet us and escort us to his room. During outside meetings, he came to the office himself to get us. Since WTHS is a large school, this was time-consuming, both for the student who had to miss a good portion of class and for us needing to arrive early knowing that we would be spending a fair amount of time waiting in the office. Halfway through our third term, the office staff became familiar enough with us to let us go to the classroom unattended on Mr. Gusek's request. Since, if this IQP continues, there will be different WPI students going into WTHS next year, they will have to earn the school's trust again themselves, but hopefully it will take them very little time to do so.

F. Goal evolution

This project was built off of George Chyoghly and Keegan Richey's "A Future Scientists and Engineers Club for Worcester Technical HS". Though they were in the second year of this program as a WPI IQP, they were the first WPI students to attempt the club at WTHS. Their major problem was a time delay in being allowed to enter the schools while waiting for CORI background checks, which are necessary in the State of Massachusetts to be sure those that those working with children have no criminal history, to clear. After hearing about this problem, one of our goals (a common goal throughout all five project groups) was to start the club in September, as early in the school year as possible. We felt that starting it up right away would make our presence understood by and expected from the students and help spark the students' interest in the class. Also, one

major benefit to this plan was that early entrance would allow us to assist with more lab sessions. Thanks to the submission of our CORI forms in D-term 2007, we successfully gained entrance to the school right away, but this unfortunately did not lead to doing many labs with the students.

One of our original expectations was to work with the students the equivalent of every other week. In reality, because of WTHS's schedule, we would go work with one class and then do an identical lab with the other class the next week. After two weeks off, we would do the same thing again. With this lab schedule, we were expecting to go to the school at least six times, four times before winter break and twice afterwards. However, shortly after "Lab Equipment Day" with each group, we were informed of standardized testing, assemblies, and other classroom disturbances as they came up. It became clear fairly quickly that we would not have as many meetings as we had hoped.

When we realized that we would not have as many meetings as we wanted to, we thought that obtaining enough data for a gender and race study might not be possible. After discussing the possibility of a new study, we decided to keep that idea but also try to learn something else while at the school. We also knew that as a collective group between all five schools, we wanted the clubs to be successful in the indefinite future and not just for this school year. This information led us to decide to also try to determine how useful our presence was in the class. We hoped that we would increase the attendance, participation, grades, and morale of the students, encourage more of them to attend college, and take some of the workload off of the teacher just by assisting them with labs. If we achieved at least one of those goals, being in the school is a service to the

system. If not, then the club is ultimately unsuccessful and should not continue in future years.

At the beginning of this class, we thought that the class was going to be run differently. We expected to run a lab instead of a demonstration. We planned on splitting the students up into groups and have each run a few different trials, subsequently taking the data and analyzing it on their own or in small groups. However, it appears as though Mr. Gusek did not have plans for such a procedure, and we had to improvise, explaining our demonstration as we ran it. This all but ruined our last possible hope for the project, which was to gather data pertaining to how learning relates to group size. Despite this, the project still had some value in that we were helping in the learning of the students of WTHS.

As time passed on, we realized that the few visits to the school that were still expected were also not going to happen as planned. It became more and more clear that our plans were not sufficient to make an impact in these physics classes. Towards the end of our project, we decided that it would be worth more to find the source of our roadblocks, examine what we could have done to make the club more successful, and present this knowledge for next year's group to build upon. Along with that, we resolved to maintain the ties and improve communication with the high school to make next year's project easier.

G. Challenges

One of our biggest issues was communication trouble between our group and the faculty at WTHS. We wanted to create a solid plan over the summer to start working with

the students as soon as possible at the start of the school year. However, most of the WTHS staff does not spend their whole summer preparing for the school year and our summer emails went unread. Also, throughout the year, any busy periods with standardized testing in the school caused a period with no email responses.

Another problem was the exceptionally busy school year at WTHS. Our original idea was to plan the project A-term, work with the students in B-term and analyze our results C-term. However, due to standardized tests, assemblies, and other classroom interruptions, the students fell behind in the fall. Because they fell behind, Mr. Gusek didn't have time to run labs with them, and had no reason for us to come in. Because we were unable to come in until the middle of C-term, we only had a chance to work with each group of students once.

A smaller problem that we faced was the simple fact that we worked with a physics class. Our group members major in Biology and Computer Science, neither of which depends on physics. Both members had only taken two introductory physics classes similar to the ones taught at WTHS, both taken two years ago. Most of this knowledge was not regularly used and difficult to remember. This obstacle was passed simply by reading, studying, and understanding the material relevant to the classroom demonstrations.

H. What we hoped to achieve

From the beginning of the project, we hoped to help explain why so few women and minorities enter the fields of engineering. There is a major gender gap and racial gap in almost all science, technology, and engineering fields so we sought out to explain that

gap. Since WPI students can be of great influence to local high school students, we also wanted to increase contact between WPI students and the faculty at WTHS. Doing so would hopefully lead to more presence in the school and setting a positive example for more of the students. Lastly, we wanted to motivate high school students to apply to college that may not do so otherwise.

As many studies along with simple observation show, science and engineering fields are dominated by White and Asian males. We wanted to not only reach out to women and minorities, but help to establish reasons why this domination exists. Eventually, others would hopefully study the same topic, and beyond that, educators would use this knowledge to reach out to women and minorities. A very distant goal is that one day, racial and gender inequalities in the fields of science and technology will no longer exist.

One problem that has plagued most of the groups involved in this project over the last two years is communication with the high schools. A big problem last year was that the CORI background checks were not completed and passed very quickly. A big problem this year was that some of the previous club advisors were no longer teaching in Worcester and nobody at the school knew what to do with the club. We planned on keeping good communication with both Mr. Gusek and Mr. Chaparian to avoid potential problems for the next group.

By working in an honors physics class, we would see the brightest potential future scientists of the high school. Because of the nature of this school, many students plan on entering straight into the workforce upon graduation. Almost half of the students plan on attending a 2-year college, but very few plan on attending a 4-year college – 17%

compared to 39% at the next lowest school. To become scientists and engineers, these students are going to need to attend a four year college. We hope that our presence, and hopefully continued presence of WPI students in WTHS will motivate students and increase this number.

II. Process

A. Project Initiation and Preparation

We first learned about the “Future Scientists and Engineers Club” project when it was presented as part of the on-campus IQP fair held in C-term of 2007 by its previous advisor, John Wilkes, and Amanda Cox, a WPI student who took over much of the work in continuing the project and worked at South Community High School at the same time that this project was run. After several meetings with Professor Wilkes, Amanda, and all of the other interested students it was decided that this was the best option to complete the IQP requirement. Once enough students were interested that at least two students could go to each of the five high schools in Worcester, it was necessary for us to find an advisor. The team, consisting of eleven students, was looking for ideally five advisors, though if there were challenges in doing so it was acknowledged that the situation could be worked out later. Professor Wilkes, who had advised the project in the past, remained available for suggestions, but was not able to advise the actual project. All of the teams struggled to find advisors, but in the end, five were found. Amanda, as the project leader, assigned two students to each school, except for South Community High School, which was given three students. The schools were assigned based on preference and availability of transportation, and an advisor was then randomly assigned to each group. Our team was assigned to work at Worcester Technical High School and our advisor was Professor T. H. Keil of the Physics Department. From here, it was just a matter of setting up meeting times our advisor, filling out the necessary CORI and IQP Registration forms, and getting a hold of the contact at the assigned school. This phase of the project was done in C- and D-terms of 2007, as well as over the summer of that year.

B. The First Planning Meeting

After initial difficulty in contacting the teachers at WTHS with which we would be working, we finally got a response from Oz Chaparian, the Science Department Head at the school. He forwarded our e-mail to Tom Gusek, the Honors Physics teacher with whom the team from the previous year had worked. We set up the first face-to-face meeting for September 12, 2007. At this meeting we met with Mr. Gusek and Mr. Chaparian to work out the basic details of the project. Since many WTHS students take apprenticeships or internships or jobs after school, working with an after-school program was going to be next to impossible. Instead, it was decided that the best course of action to take would be to work with the students in a given class during school to help the teacher run more complex activities like labs as well as work to stimulate the interest of many of the students in college since many of them were unsure as to whether they would end up attending a college. Several options were presented. The first option was to work with Mr. Gusek's Mechanics class, a physics class that consisted of juniors. The second option was to work with Mr. Gusek's Electricity and Magnetism class, which consisted of seniors. Finally, the third option was to work with the new Advanced Placement Biology class that had recently been started at the school. The previous group to do their IQP at WTHS had worked with Mr. Gusek's Mechanics class. Many of these students had moved on to his E&M class, so it was decided that any data that had been collected by the previous team would essentially be identical to what our team would collect in that class. Since, at the time, our team was looking to collect data of the interest in science and engineering, based on gender, race, and other such factors, the AP Biology class did

not seem to be a wise choice either since it consisted of only nine female students. This not only eliminated one factor we were looking to examine, but also had too small of a sample size to yield any credible data. Thus, it was decided that the best class to work with would be Mr. Gusek's Mechanics class.

C. The Second Planning Meeting

The next meeting did not happen until October 24, 2007. The purpose of this meeting was to work out exactly what the role of our team would be in the Mechanics class. Mr. Gusek explained how his classes were run and how he was looking to be able to run more labs. Due to time constraints, he usually was not able to successfully run a lab in the class; however, his hope was that with our team's assistance plus a wide selection of new equipment he would be able to run labs without worrying about running out of time. Although no actual times were determined, Mr. Gusek promised that he would be in touch with our team shortly in order to work out the next phase: introducing his students and our team to the new equipment, and introducing his students to our team.

D. The First Student Meeting

The following week, our team returned to the school to meet with the first group of students. The time was spent helping the students understand the capabilities of the new PASCO equipment as well as get acquainted with them. The same meeting happened the week after that, but since the schedule at WTHS has two groups of students (one working with their trade and the other working with their academics); this group was the other half of the one we would be working with. Between these classes, our team was

able to understand the equipment ourselves, as well as meet the students and get an idea of the group we were to be working with. At the conclusion of these meetings, Mr. Gusek promised to be in touch with our team, and would tell us when he planned to run his next lab.

E. The Third Planning Meeting

On January 18, 2008, we met with Mr. Gusek at WTHS to begin discussing a more specific role for our team in the school. Mr. Gusek informed us that he was going to start teaching Newton's Second Law, $F=ma$, to his students the following week and he wished to do a lab to demonstrate it. He wanted us to plan the lab because he was short on time. He planned to use a straight, flat track and a cart to imitate Newton's original experience. The track was to be placed on a lab table, and the cart, once on the track, would be attached to a mass on the end of a string that went over the side of the table via a wheel. When the mass was released, it would fall almost to the floor, and the cart would accelerate to the end of the track. The mass on the end of the string provided a constant force, and as the mass of the cart increased, the acceleration would decrease. The position of the cart over time would be measured by an apparatus that sent that data directly to the PASCO software on an attached computer, which would be able to calculate and graph position, velocity, and acceleration. These graphs could all be projected onto the board for the students to see and come to understand the relationship between each of the concepts. The lab was to be short, as there was a limited amount of time in the period for the students to be able to conduct it, plus equipment was limited because there was only one track. We were obtained the PASCO software from WPI on our own computers in

order to set up the parameters so that the experiment could be run immediately at the start of class. This set the stage for our first real interaction with the students.

F. The Second Student Meeting

On January 24, 2008, we went for the first lab. This visit ended up being useless to the class, as we never got to run the lab. We arrived later than we planned on, and ended up not getting all of the equipment set up with enough time left to run the demonstration. Additionally, we had not installed the PASCO software completely, and the hardware was not ready for use with our computers. The hardware drivers did not install when the DataStudio software did because no hardware was connected at the time. This problem had not been anticipated, and thus we were not prepared with the install disk to install the drivers upon arrival.

In light of these failures, we arranged another meeting the following day to install WTHS's newer version of the software (including the missing drivers). We had some difficulty installing the software at first but then figured out how to be sure the drivers were installed. We also arranged to go back the following Friday to try again with the next group of students. In the days leading up to that, we planned our departure and setup procedures more carefully. We had additional time assurance because the equipment was still partially set up from our last trip. We also made sure that the software would be ready to recognize the hardware and produce the necessary tables and graphs for the lab.

On Friday, February 1, our team returned to WTHS to try again. We left significantly earlier, did not have to wait for a student from Mr. Gusek's first class to pick us up from the office, and already had the equipment set up, leaving us with an extra half-

hour before class. The class arrived and, after a brief introduction by Mr. Gusek, we got the floor. The cart came with two mass blocks that fit into a tray on its top, so we began the demonstration with one block in place to get some baseline data. This demonstration worked flawlessly. The position graph was a perfect quadratic curve, the velocity graph was perfectly linear, and the acceleration line was perfectly horizontal. This allowed the students to see the relationship between the three, thus completing one major goal of the lab. Next, we ran the experiment again, only this time with no mass block in the tray. The system once again worked perfectly. The position graph had a sharper curve and ended sooner, the velocity graph was still linear with a steeper slope, and the acceleration graph was still a horizontal line, albeit with a greater y-coordinate than the first run. We ran the experiment three more times: the first with twice as much mass as the first trial, the second with as much mass as we could pile onto the cart, and the last with two mass blocks and a greater force at the bottom of the string. Each trial yielded ideal results, demonstrating excellently Newton's Second Law. By the conclusion of the class, we had accomplished the mission Mr. Gusek had had in mind for us, which was to show how Newton had arrived at this fundamental law of physics.

On Monday, February 4, 2007, we returned to perform the same demonstration with the next group of students. This was the same group of students we had been planning to work with the first time around before our poorly-planned outing the first time; however, this time the class was better-behaved and we were better prepared. The demonstration once again was carried out very well, with the only glitch being a faulty motion sensor that was quickly replaced. Once the class had concluded, we informed Mr. Gusek that we could continue to come and help him, but our availability was going to be

drastically limited, as we now had the task of completing the paper and our D-term schedules were going to be much more difficult to work around. He told us that he understood, and would take our help whenever he could get it. With this, we completed the school visits of our project.

III. Conclusions

A. Overall Conclusions

Although our project did not have the results we intended for it to have at the beginning, it was nonetheless a successful continuation of the concept. Rather than yielding data that may help augment the interest of female and minority students in science and engineering, it ended up being more of a guide for future participants in the IQP. The hope is that the information we gathered and suggestions we can make based on our experience at WTHS can help the project to grow more successful in the coming years, and eventually reach our original goal of making science and engineering more appealing to women and minorities to reduce the disparity of these fields today.

B. Recommendations to Future Groups at WTHS

As was mentioned at the beginning of the paper, conducting this project at WTHS is very different from conducting it at any other school. Some of these differences made the project more challenging; however, there were some challenges at other schools that were never a problem at WTHS. For example, although the project needed to be conducted during the school day and thus was very specific and regimented due to the curriculum, the number of students and participation remained relatively constant throughout the year. Based on our experience, we can make the following recommendations to future groups in order to maximize the success of their projects at WTHS.

First of all, beginning the project early is always a good idea. The State of Massachusetts takes CORI forms very seriously, and it will take a while for them to

process it. It is best to submit the form during the D-term prior to the beginning of the project. Likewise, WTHS is a government organization, and is entrenched in bureaucracy. It will take a long time for most ideas to be approved and implemented because there are so many officials who must approve of it first. Thus, planning is a very important part of the project, and it is always a good idea to act on plans right away. An example was our plan for a field trip to WPI. Although the idea was feasible and a great idea to garner interest in college, there is a lot that needs to be done on the school's end for such an idea to take off and thus it is important to get it noticed and approved very early in the project.

Another important recommendation is to make sure to work out a specific role with the instructor. For example, Mr. Gusek had a different definition of a lab than we did. We were expecting to set up equipment for students, having them run the experiment, and then using the data to answer questions once the lab had been completed. However, Mr. Gusek's intentions were for us to do demonstrations to show how a concept worked. If future groups intend to do labs instead of demonstrations, it will be important to establish that with the teacher and plan it out carefully. Otherwise, it is likely that demonstrations will be the extent of the group's participation. While this is still useful for the student's learning, it yields no actual data that can show the interest levels of women and minorities in science and engineering.

Finally, it is important to set a schedule with the teacher as soon as possible. This is especially important if the group intends to go to the school more often than we did. One advantage to having a curriculum in place is that a teacher knows what he is going to be teaching the students at different times throughout the year. This can be used as a guideline, and using it the group can establish when they should come to the school early

in the project. Waiting for the teacher to contact the group, much like we did, results in very few trips to the school. Planning out ahead of time will give the group a chance to design a lab for the class well in advance, and when the time comes all that needs to be done is for the students to arrive at the school and carry it out. This way, the students get the advantage of hands-on work, and the group gets the interaction and data they need to determine whether their techniques are working. This is perhaps the most important recommendation of all, since it will allow a large enough sample size to be obtained for the lab to be deemed a successful study.

C. Closing Statements

All in all, this lab was successful. Although our initial goals were not met, the experience was invaluable in many ways. It was good for us to get to know the students and structure of Worcester's Public schools, and using this knowledge we can help future groups refine their techniques early on to allow for our initial goals to eventually be met someday. The experience was also good for the students, who learned important concepts in physics through our demonstrations and may have even decided to go to college thanks to our participation. Mr. Gusek informed us that one senior in his E&M class had applied to WPI, and that he had been a participant in the project prior to ours. In conclusion, this was a worthwhile experience, and should be continued in the future for everyone's benefit.

IV. Resources

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